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BACTERIAL SPECIES HARMFUL TO PETROLEUM PRODUCTS IN STORAGE

Item of Interest

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A brief report on Soviet investigations of bacterial species that may possibly be damaging agents of petroleum products in storage is presented. The report is based on literature dealing with detection and identification of 1) hydrocarbon-oxidizing bacteria, 2) sulfate-reducing bacteria, and 3) sulfide-oxidizing bacteria.

1. Hydrocarbon-Oxidizing Bacteria [1]

Microbiological methods of oil and gas exploration have yielded a great deal of data on the distribution of methane- and propane-oxidizing bacteria in underground waters of oil-bearing regions of the USSR. The methane-oxidizing bacterial species, as well as those which thrive on heavy gaseous hydrocarbons and in the process consume some methane, are the most widely occurring. Eight species have been isolated from the underground waters of Western Bashkiria, all of them related to the Pseudomonas Bacterium, Pseudobacterium, or Mycobacterium genera. These species are identical to those occurring in the soil and water of non-oil-bearing regions, in the water of the Black Sea, in Sernoye Lake, and in methane storage tanks except in their capacity to oxidize gaseous hydrocarbons.

Two species of bacteria obtained from these underground waters in a methane-containing atmosphere were very similar to the Bact. methanicum and Methanomonas methanica. These species oxidize only methane. Two other species of bacteria obtained are very similar to Mycobact. methanicum and Pseudobacterium species. They are capable of oxidizing not only methane but also its heavier homologs.

Three species of bacteria found are similar to the Pseudomon caudatus, Pseudomon liquefaciens, and Pseudobact. subluteum occurring in the soils and waters of non-oil-bearing regions, but differ in their capacity to oxidize gaseous hydrocarbons. This capacity has presumably been acquired as a result of a protracted period of adaptation to new living conditions.

The last bacterial species, obtained from underground waters in a propane atmosphere, is identical to Mycobact. rubrum var. propanicum and is capable of oxidizing only propane.

The above investigation was conducted by F. S. Smirnova, All-Union Scientific Research Institute for Petroleum Geological Exploration, Moscow. Research on the ecology of these bacteria in relation to various gaseous hydrocarbons will be continued. [1]

2. <u>Sulfate-Reducing Bacteria</u>

In 1960, Yu. I. Sorokin, aboard the *Vityaz'*, conducted an experimental study of bacterial sulfate reduction in the Black Sea using the S^{35} isotope [2]. The following are some of the findings of that study: Active sulfate-reducing bacteria are most common near Batumi, which is connected by a pipeline to the oil-rich region of Baku. Sulfate reduction is most rapid in the superficial layer of sediment along the shores and on the continental slope. Active sulfate reduction occurs in a layer approximately 5 cm thick. In the water itself, sulfate reduction was detected in the upper hydrogen sulfide zone. The yield of H_2S was about 2 mg/l of mud in 24 hours. The preliminary findings will be supplemented by a detailed study of bacterial sulfate reduction in other locations on the Black Sea which will also be undertaken in the vertical direction. Special attention will be given to those layers of ground and water where the rate of the process is maximal. [2]

Some information on the adaptability of sulfate-reducing bacteria to different nutrient media has been obtained from a study [3] of the biogenic formation of hydrogen sulfide in deep mineral waters of the Caucasus. It was found that four groups of mineral springs contain sulfate-reducing microflora. The same strains of the sulfate-reducing bacteria can be both heterotrophic and autotrophic. The biochemical formation of hydrogen sulfide in mineral waters is based on the consumption of organic compounds contained in the water and the rock through which it filters. By utilizing additional molecular hydrogen, the autotrophic bacteria produce more hydrogen sulfide. Laboratory experiments have shown that sulfate-reducing bacteria are in fact able to utilize organic compounds. The amount of hydrogen sulfide produced is proportional to the amount of organic compounds added. In an atmosphere of molecular hydrogen, the production of hydrogen sulfide is also increased. [3]

After establishing the fact that sulfur-reducing bacteria produce hydrogen sulfide in water, crude oil, and gas, and accelerate the corrosion of equipment used in the petroleum industry, the Institute of Microbiology, Academy of Sciences USSR, has investigated the possibility of suppressing the activity of sulfate-reducing bacteria [4]. Fresh water from Devonian horizons of the Volga-Ural oil-bearing region, which possesses bacteriostatic properties, was used in the experiments. Laboratory tests showed clearly that dilution of stratum water from oil deposits with fresh water from the Devonian formation, which has a high

concentration of calcium chloride, suppresses the activity of sulfate-reducing bacteria. But in order to obtain a sufficient level of suppression activity, as high as 40% of the water with bacteriostatic properties would be required. [4]

3. Sulfide-Oxidizing Bacteria

Information on properties of sulfate-reducing and sulfide-oxidizing bacteria and their interaction was obtained in a study [5] by G. A. Sokolova of species of bacteria of Sernoye Lake in Kuybyshev Oblast. Sokolova's study makes use of data of K. Butlin and I. Postgate (Biol. Deserts [sic]. London, 1952. p. 112) on the formation of sulfur in certain African lakes. According to them, sulfur is produced by sulfate-reducing and purple sulfur bacteria together. A tremendous amount of Thiobacillus thioparus was found in layers of Sernoye Lake that were rich in molecular sulfur and in surface films of fresh sulfur deposits. Sokolova concluded that sulfur is formed primarily by sulfide oxidation by the Thiobacillus thioparus in the most superficial mud layer and, partially, in the water of the lake. [5]

The importance attached to this research may be surmised from the special report by Sokolova to the Moscow Section of the All-Union Microbiological Society on Thiobacilli in underground waters, oil, and sulfur deposits [6].

In a recent study [7] of biochemical transformations of sulfur, a new species of purple sulfur bacteria was found by M. Ye. Gambaryan in Sevan Lake. A culture of purple sulfur bacteria was isolated from a medium containing numerous pigmented and colorless sulfur bacteria. Microscopic investigations established that the culture is comprised of oval cells -- (2.5 to 3.5) x (3.5 to 4)μ -- connected in groups of fours and twos and individual round cells (3.5 μ average diameter) immersed in a gelatinous mass. A certain similarity of this culture to Thiopedia rossea was established. However, on the basis of differences in reproduction, size, and pigmentation, the new culture was assigned to a discrete species, Thiopedia sevani (n. sp.).

COMMENT:

It must be noted that no direct information on the damaging effect of any bacteria has been found as yet in Soviet periodicals on petroleum technology. However, indirect information (as cited in this report) is available in the biological periodicals, and there are indications that the Soviets are interested in possible damaging species, but do not clearly indicate the reasons for this interest. In one case, the corrosive effect of H_2S produced by sulfate-reducing bacteria on the metallic equipment of oil wells is mentioned in [4].

The studies reported here can be considered as being in the stage of preliminary basic research. It is believed that this information can be useful from the standpoint of comparison of Soviet bacterial flora with that of other countries, of adaptation of bacteria to different living conditions, and of suppression of bacteria life functions by modification of the surrounding medium (in this case, water).

References

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